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ABSTRACT

Possible future developments in artificial intelligence (AI) as well as its limitations are considered that have implications for institutional research in higher education, and especially decision making and decision support systems. It is noted that computer software programs have been developed that store knowledge and mimic the decision-making abilities of experts. In order to picture possible future developments in AI and the possible effects on institutional researchers, an exercise in creative imagination for decision-making in the year 2001 is presented. It is noted that AI expands the capacity for memory, recall, association, and other capacities of human intelligence. AI is limited in terms of the function of integration. In addition to integrating the individual aspects of the mind itself, human intelligence can integrate other functions such as the emotional, sensory, and experiential domains, all of which may be important in decision-making. The institutional researcher of the future may help design sophisticated AI software that will require knowledge across a number of disciplinary fields and the ability to integrate these fields with expert system decision-processing software. 33 references. (SW)

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# Decision-Making and the Interface Between Human Intelligence and Artificial Intelligence

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# Decision-Making
# and the Interface Between
# Human Intelligence and Artificial Intelligence

## Abstract

It is likely that a relatively new development in technology will increasingly affect the process of decision-making and the development of decision support systems. Computer software programs have been developed that store knowledge and mimic the decision-making abilities of experts. It is estimated that the market for this type of software will increase ten-fold by 1990. These commercial enterprises will be expedited as research at university centers such as the Center for Applied Artificial Intelligence (CAAI) develop software that simulates human thinking processes and decision-making by experts.

This paper explores the possible revolutionary implications of the preceding developments for institutional research, especially decision support systems. In addition, there is the conclusion that artificial intelligence (AI) can not replace human decision-makers.

## Purpose

The purpose of this paper is to: (1) Stimulate thought and research among institutional researchers concerning Artificial Intelligence (AI) and its implications for institutional research, especially in reference to decision support, and (2) Discuss the limitations of AI and the continuing need for the human decision-maker, and the institutional researcher, in the light of the components of decision-making. Although the purpose here is not to present a history of AI or a discussion of the technical issues that have evolved during its development, the references and the bibliography provide this information.

## Introduction and Perspective

DM Data of Scottsdale, Arizona has estimated that the current $74 million market for Expert Systems that includes simulations of decision-making by experts will increase to $800 million by 1990. The preceding and other developments in artificial intelligence research represent a quantum leap in the continuum of trends. Some decision-makers have interacted with personal computers in the process of decision-making and institutional researchers have provided varied types of support--data/information, software, approaches to asking "what if" in queries of data, the use of simulations and modeling, consideration of the results of environmental scanning, and assistance in the use of personal computers. The new research in AI can enhance these endeavors because some of the limits of rationality will be changed in that a single human mind will have access to values, knowledge, data/information, and decision-making processes that were not available in such quantity (and perhaps, quality) previously.

In order to picture possible future developments in AI and the possible effects on institutional researchers, first engage in the following exercise in creative imagination related to the year 2001 or later and consider the extent to which sweeping and rapid changes may come in the profession. Following the fantasy or use of creative imagination, come back to earth and consider the following: (1) Whether the fantasy can become reality by 2001, (2) The trends and current characteristics of decision-making in the light of potential future directions and how decision-support can be provided, (3) Discussion of the functions of human intelligence and artificial intelligence and how they may interface in the decision-making process and, (4) The limitations of the use of AI in decison-making and the possible elevated professional position of the institutional researcher as developments occur in the use of AI by the human decision-maker.

An Exercise in Creative Imagination

Decision-Making in 2001 or Later

President I.M. Futurmann has just returned from a meeting with the Board of Regents of Statamania. He has been given ten days to decide whether he will cease and desist from his demands and activities related to increased institutional autonomy in control over academic programs and the allocation of resources within the University. President I.M. sat down at his desk and turned on the Macro-Intelligencer (once termed a computer). Several small red lights come on in sequence and then a voice says, "I am ready." I.M. keys in his code name and says it verbally in order that the dual match will provide security. With security established, he is free to talk to the Macro-Intelligencer which he calls "M.I." President I.M. briefly describes the meeting with the Board, states the problem and the decision that must be made. He must wait while M.I. installs the decision-process program

(software) developed by the Chief Consultant/Advisor (formerly known as the Vice President of Institutional Research). A few seconds later, M.I. reports that the program is installed and the data/information file on the Board and the personality characteristics of its members is being accessed and correlated with the data/information file on the issue of autonomy and the history of the issue that became pronounced in the 1990s. A full two minutes later, M.I. states that the problem with the Board is fear that President I.M. wants to return to the past when universities competed with each other for funds and wasted money protecting turf. The Board fears that this would result in the huge state deficits caused in the 1990s by wasteful spending and declining revenues due to foreign competition in the production of goods and services. President I.M. had not picked up on the fear element during the meeting. He told M.I. that he thought the issue was power and he wanted to attempt marshalling forces to fight. M.I. then recalled incident after incident in the data/information file that supported the fear thesis. When President I.M. entered into discussion with M.I. on possible approaches to the problem, the interaction resulted in the conclusion that the best approach was to shift the discussion with the Board from autonomy to efficiency in the use of funds and the contribution the University's Department of World Business and Technological Culture could make in enabling the state and federal governments to compete more effectively with foreign trade.

After President I.M.'s interaction with M.I., he called in Chief Consultant/Advisor Jim Wise and asked his views concerning M.I.'s analysis and the proposed approach. Jim had developed the program that M.I. used and he had worked with M.I. in refining it. He trusted the results, but he would test them by working with M.I. to develop a plan for implementing a proposal

to the Board for cost-savings without compromising academic quality and for utilizing the Department of World Business in dealing with foreign trade and increasing state revenues. After the plan was completed, it would be processed through M.I. and tested by criteria that were developed from and based on the voluminous data/information files on cost-savings/academic quality and on foreign trade. Both of these files contain data and information which, if it were in books, would require years of constant human reading. Some of the information and data are not available in hard-copy. If the plan passed the criteria test successfully, it would then be correlated with the data/information files on the decision-making behaviors of the Board and personality characteristics of Board members in order to determine the probability that the Board would accept the plan and divert attention from the issues of institutional autonomy.

Thus ends the exercise in creative imagination. Obviously it is limited by one's difficulties in extending knowledge and perceptions into the future, but it does provide a picture of the potential uses of AI by decision-makers in the future. In addition, the picture suggests that the institutional researcher of the future may be trained as a scholar in how to access and utilize knowledge in multiple disciplinary areas such as economics, politics, history, psychology, science, and technology. This knowledge could be integrated with the data/information file on decision-making processes and then applied to the development of sophisticated software that could access these vast and varied files and then engage in thinking processes patterned after those of the best of human minds.

## Will the Fantasy Become Reality by 2001?

Is it possible that the picture produced by creative imagination will be reality by 2001? Persons engaged in institutional research who work with

state-of-the-art hardware and software may well respond that developments in AI will make it possible to approximate a number of the aspects of the fantasy, but that some of the intelligence attributed to the computer may not be realized by 2001 or even later. The knowledgeable reader may well agree, based on recent articles that have appeared in sophisticated publications. Fortune Magazine (December 22, 1986, p.161) carried an advertisement of Texas Instruments' Explorer System that explained the Explorer Mega Chip stating, "On the horizon are machines that will communicate in a language everyone understands; speak, hear, and see; solve complex problems requiring inference and deduction; and help make complicated and subjective decisions." The founder and Chief Executive Officer of Analog Devices, Inc. affirms that these are probabilities. He stated "I think machine vision will become a reality in the next five to ten years, to replace hordes of quality inspectors ...Speech recognition will become available in the next decade,too, and office workers will be able to give computers voice commands," (Fortune, February 2, 1987, p.62). Currently, inroads have been made into the voice command software, applicable to desktop computers, such as Pronounce Voice System designed by Microphonics Technology Corporation of Auburn, Washington (Boulder Daily Camera, September 28, 1986, p.6c). Combinations of the preceding research and development in industry and the research in Universities have increased rapidly since 1980. An example is the Massachusetts Institute of Technology and what is called "intelligence alley," an area of about two-thirds of a square mile in East Cambridge, Massachusetts located close to MIT's artificial intelligence laboratory. This area consists of a number of small enterprises devoted to artificial intelligence and computer software. Since 1980, these small businesses have created more than 20,000 jobs, exceeding job growth in 13 states, according

to David L. Birch, director of the Program on Neighborhood and Regional Change at MIT. Another example of how university research is being applied is the Center for Applied Artificial Intelligence (CAAI) at the University of Colorado. A small business, Management Robotics, Inc. was created by Dr Claude McMillan as a result of research in AI. Dr. McMillan explains other applications of AI, e.g., medical diagnosis. He states, "The expert, with intuitive human knowledge, puts into the system his thoughts as the diagnosis progresses. Ultimately, the problem is solved. Meanwhile, the methods of the expert are retained by the computer, and later users will get the benefit." (The Colorado Alumnus, September, 1986, p.5)

The rapid pace of research and development in the applications of AI and the current capabilities of expert systems provide a reasonable probability that by 2001 that which was described as fantasy or creative imagination will, at least in part, be reality.

## Decision-Making and Decision-Support

### Trends and Current Characteristics

In order to place the developments in artificial intelligence in the perspective of decision-making and decision-support, it is necessary to view the trends and current characteristics of these activities in the light of potential future directions.

The trends and changing characteristics of decision-making are indicated by Simon (1945, 1947, 1957, 1976) who provides a historical perspective on decision-making theory and practice over a 31-year period of time. These volumes are like an odyssey through decision-making as decision theory and practice moved from scientific management to an organizational behavior orientation and on to decision-making with a psychosocial base that recognized and included the human elements which are beyond the rational.

With the development of management information systems and now artificial intelligence, decision-making has emerged, and will likely continue to emerge, into new phases that capitalize on preceding developments by combining the rational, the technical, and the sociopsychological elements.

Concerning the trends and future directions for decision-support, much of the emphasis in the late 1970s and early 1980s is representative of the development of computer hardware, software, and management information systems. For example, publications of the National Center for Higher Education Management Systems emphasized the needs for data and information (Jones, 1982) and rationality (Chaffee, 1983) in decision-making.

Two publications of New Directions for Institutional Research (1977-no. 15 and 1986-no. 49) provide "snap-shots" that indicate nine years of the changing, developing interests of institutional researchers in the ways decision-makers might be served. The 1977 issue included subjects such as information needs, information systems, higher education governance in relationship to information systems, processing and communicating data, and information support for decision-making. By 1986, the phrase, decision-support system (DSS) was being used. Earlier, Moore and Greenwood (1984, p. 2) traced the historical development of DSS and pointed out that, in the 1980s, DSS provided a mechanism that enabled the decision-maker to interact with an integrated system of a data base and decision models. The 1986 New Directions for Institutional Research revealed the development of institutional research from a preoccupation with providing data and information, as indicated by the 1977 issue, to an emphasis on decision-support systems. This was evident by the phrases being used, such as tactical decision-support (also, cf. Chaffee, 1983), decision models, strategic decision-making, and group decision-support systems. In the 1986

publication, Rohrbaugh traced DSS back to Herbert Simon (1958) and carried it forward to recent technical developments such as artificial intelligence and the use of sociopsychological research. Rohrbaugh states that the design of DSS needs to concentrate on decision-makers rather than on decisions (after Bahl and Hunt, 1985, p. 87). He points out that the technical work on DSS is as distant today as it was in 1970 from such fields as behavioral decision theory, organizational development, group dynamics, and organizational behavior. Rohrbaugh concludes that DSS applications will be advanced by better understanding of decision-making behaviors. This, of course, is in the direction that AI is moving.

One can conclude that, if Rohrbaugh is correct, decision-support in the context of institutional research has a long way to go in order to accommodate the profession to the emerging developments in AI. In addition, there is great distance between the current directions of institutional research and the fantasy which portrays the institutional researcher in 2001 as a multi-disciplinary scholar who can apply knowledge from many fields to the art of decision-making and decision-support.

## A New, New Direction for Institutional Research

### Research in the Interface Between Human Intelligence and AI

The previously described comparisons between the 1977 and the 1986 publications of New Directions of Institutional Research demonstrate that the profession is developing and growing in depth as responses are made to needs that arise in higher education. The problem that may be encountered, however, is that the profession will be captive to a knee-jerk response to the crisis stimuli which will be emitted increasingly from higher education institutions within the foreseeable future. Although it is necessary to respond to institutional needs in order to keep place and position, it is also necessary

to think beyond the present mileau of needs in higher education to more distant times and more distant needs that administrators do not yet see because they too are experiencing knee-jerk spasms as Legislatures, Regents, or Boards of Trustees exert all manners of pressures as the race for funds becomes more competitive and more exhausting.

A new direction for institutional research could well be research and thought related to the interface between human intelligence and artificial intelligence, especially in the activity of support for decision-makers. If this possibility ignites a gleam in the mind, perhaps the map to follow in such thought and research is one that allows for changing directions as frequently as necessary when new knowledge becomes visible over the brow of a hill on the road that is being traveled.

The map for new directions must include a starting point and flexibility in determining the direction to take. Flexibility means avoiding becoming locked into an extreme pro-artificial intelligence stance or an extreme anti-artificial intelligence stance. If increasing numbers of institutional researchers become engaged in research related to artificial intelligence and its potential for use in decision support, the discoveries may produce strong opposing positions. On one side, some may have extreme confidence in artificial intelligence and they may believe that the computer can do nearly everything desired; on the other side, some may have much less confidence in artificial intelligence and they may believe the computer is dehumanizing, therefore, extensive use of it should be shunned. Contrasting these extremes, the researcher will be flexible and open in exploring the uses and benefits of artificial intelligence, but will not be dazzled into blindness that prevents insight into the limitations of this phenomenon. This quality of openness and flexibility will be furthered by the choice of a starting

point. The starting point is to ask appropriate questions such as: What does one mean by human intelligence and artificial intelligence; what are the components of decision-making and how can the "two intelligences" interface in decision-making; are there strengths and limitations of artificial intelligence as well as human intelligence? The last question will be dealt with in the next section. Concerning what is meant by human intelligence and AI, the map of new directions describes rather than defines because definitions are often more restrictive and less suggestive. This is particularly true when considering the interface between human intelligence and artificial intelligence that is apt to prompt definitions of terms ad nauseum. Gardner (1985, p.140) describes the difficulties that have been experienced by experts in attempts to define AI. For useful purposes here, the description of human intelligence is by observed functions. Consider some functions of intelligence: Memory, recall, association by comparison or contrast, uses of analogies and symbols, the exercise of forms of reason such as induction and deduction, the use of logical forms such as syllogisms, and perhaps intuition and other capabilities not presently understood. A useful description of artificial intelligence is that which is created by human mind or minds, i.e., computer software, and performs some or all of the functions of human intelligence. These descriptions of human intelligence and artificial intelligence suggest the ease with which these two kinds of intelligence can interface. Basically both have similar functions because the development of artificial intelligence was patterned after that which was observed in human intelligence. Once it was learned that computers could store "memory" in silicon chips, this was the keystone for future building blocks that led to a simulation of other functions of human intelligence. [See Newell (1983) and Gardner (1985, ch.6) for descriptive histories of AI].

Consequently, artificial intelligence is an extension to and a complement of human intelligence. It is an extension in that it expands the capacity for memory, recall, association, and other yet to be developed capacities. It is complementary in that it corresponds to the counter-part characteristics of human intelligence, forming a kind of partnership between the human and his creation which is called a "machine"--a computer.

Human intelligence and artificial intelligence also interface in the context of the components of decision-making. What are the components of decision-making? Observations reveal that they vary in accord with differing situations and differing personalities of decision-makers. Some observed components are: The use of technical or expert advisors, data and information, analysis and synthesis related to data and information, personal experience and observations, values, knowledge, political considerations, the need for personal survival or survival of the institution, a feeling of deja vu--having been in a similar situation before, intuition or feeling in a situation, and finally, organizational factors that are components of decision-making such as institutional mission, goals, objectives, plans, and institutional characteristics.

As one considers the components of decision-making and recalls the achievements and future potential related to artificial intelligence, it appears evident that artificial intelligence could perform many of the functions of decision-making. If that is so, does that mean that in the future there will be no place for the human decision-maker? Are there limitations to AI and if so, what are they?

## The Limitations of Artificial Intelligence

### The Future Need for Decision-Makers and Institutional Researchers

It may seem presumptuous to attempt identifying both the possibilities and the limitations of future research and development in the area of artificial intelligence. Having had the temerity to confront the possibilities, it is quite necessary to consider the limitations in order to attain a balanced perspective.

The future limitations of AI may be in the very area of its strengths--that AI simulates human intelligence and thus has both the strengths and weaknesses of human intelligence. In addition, there are other limitations. A perceptive human being is capable of being aware of his/her limitations in intelligence. A computer does not have this human characteristic and thus can make all sorts of mistakes due to this lack. The open question in viewing the future use of computers and AI is how closely it will be possible to simulate collective human intelligence. Even if in the process of decision-making, for example, computers armed with sophisticated AI simulated the intelligence of experts, would it be possible to access the best or most appropriate expert for a given situation? And, experts can be wrong or incorrect or inept in certain situations and under certain conditions. This creates a danger for future man if he assumes the computer, using Expert Systems software, is infallible and yet the fallibilities of the experts have been programmed into a slick system, so bright that its glare dazzles the user.

The limitations of the future possibilities of AI may center on distinctive characteristics of human intelligence that curiously enough are not likely to be copied or programmed into a computer. There seems to be a Gestalt factor in human intelligence in that the whole is more than the sum

of its parts. Thus, individual traits or characteristics of human intelligence could possibly be programmed, but the spontaneous interaction of these traits, the integration of the separate traits into a given activity at a particular time--here is the point at which the limitations of AI may become evident and confront an insurmountable barrier. One of the chief functions of mind or human intelligence is the function of integration. It integrates not only the individual aspects of the mind itself, but also other functions of the human being--bodily functions and the emotional, sensory, experiential aspects of the human being. It is this integration of the human being that may mean computers and AI can never replace humans. Human judgment and values, the nuances of meaning of which humans are capable, the capabilities of verbal and non-verbal perceptions, the capability of discerning personal and cultural bias that can distort perceptions and reasoning--these are characteristics of human intelligence and being human! Thus, it may well be that there shall always be a distinction between the human and the non-human--the reality that the non-human is not human!

## Conclusions

The preceding thoughts on the limitations of AI and computers need to be considered side-by-side with the realization that we are emerging into an age when that which once was considered impossible, may be possible. In the context of decision-makers and institutional researchers, this means that there will always be a place for human expertise, but that it will be necessary to look beyond the present and exercise creative imagination in preparing for the requirements and necessities of the future. In these respects, it is perhaps wise to give some thought to the fantasy previously conjured, or other future possibilities. It is conceivable that the decision-maker of the future, even though he or she ultimately makes the

decision, will use the advantages of what was termed a macro-intelligencer in the fantasy. It is also conceivable that the institutional researcher of the future will be participating in the design of sophisticated AI software that will require knowledge across a number of disciplinary fields and the ability to integrate these various fields of knowledge into a meaningful organic relationship that may be integrated with Expert System decision-processing software that is easily accessible to decision-makers who will still need the services of the human expert who provides judgments in a manner that is outside the capability of the computer.

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